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Inside

Roof and Attic Ventilation

From the Editor

I was astounded recently by a call I received from a person in Washington state. The caller asked what sort of incentives the Canadian government was offering homebuyers to build energy efficient homes. I pointed out that there were no direct incentives, other than some modest ones to encourage owners to improve the energy efficiency of existing homes. Rather than direct cash incentives, the Canadian government was providing support for research, education and training of the industry that will benefit everyone.

The caller sounded genuinely surprised that there are no grants. He could not understand that the benefit of the better quality, more comfortable home with lower operating costs should be an incentive in its own right. He did not sound pleased when I asked Why should I (through my taxes) pay him to get a better house?

I do not mean we should avoid any initiatives that will improve the energy efficiency of homes. Setting high-energy efficiency standards and encouraging lower resource consumption is something that we as a society must do. It is the only responsible thing to do if we are serious about leaving a better world for future generations. To take no action is simply irresponsible. The question is what is an equitable way to do it to get meaningful results.

We need to question our expectations as consumers and what weight we place on the inherent value of the products we make and use. We know that it is possible to build energy-efficient homes that can meet at least the R-2000 standard without significant incremental costs. It may mean some adjustments to expectations about the kinds of features that are included, but it is doable. We just have to act rather than pay lip service to the idea.

Given the many hidden subsidies the energy industry receives, perhaps the caller was not off the mark in looking for handouts. The downside of an economy where marketing is done with handouts or rebates is that it leads to a false economy where much trade becomes trade in incentives and rebates, rather than in the inherent products. In the late 1970s, the US introduced tax credits for solar water systems to help develop the solar industry. However, when the tax credits expired, the industry collapsed. It was then realized that the marketers were really selling tax credits, rather than environmentally benign solar technology. It did not help that the incentives to the oil and gas industry continued, helping to keep the price of non-renewable fossil fuels low, further distorting the market.

Noises are now being made by some within our industry – and heard by Conservative politicians – to introduce mortgage interest tax deductions in Canada, copying an American policy. Tax deductibility of mortgage interest does not necessarily make the homes more affordable or accessible, as most of those likely to take advantage of the deductions are those for whom affordability is not as big an issue. Cost and affordability are too often confused with expectations for features and appointments in the home.

If anything, mortgage interest deductibility encourages owners to maintain higher mortgages. The home becomes another disposable commodity to trade rather than to pay down, because the cost of financing is that much lower. In the short term, it may have an impact on the housing market, but in the longer term it will likely do little to it. At the same time, the lost tax revenues simply have to be replaced by some other form of tax to provide the public services the taxes are financing.

In any event, we presently have a critical shortage of skilled trades, so there is little benefit in stimulating the market further. I suspect that the main beneficiaries for tax deductibility would be mortgage lenders, as there would be less incentive for homeowners to pay down their loans.

Richard Kadulski,
Editor

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Roof and Attic Ventilation

Buildings must be durable and able to withstand the elements acting on them. The intent of specific code requirements is based on sound building science principles. How these are applied must also take local climatic conditions into account. Over time construction practices and materials may change, but codes and standards may not adapt quickly enough to keep pace with the changes. This could be the case with code requirements for roof and attic venting details.

Building codes typically require attic ventilation. The intent is to manage moisture in the roof by avoiding condensation on the framing and underside of the roof sheathing. Summer cooling of attic air, minimizing ice dams, and extending the service life of the roof materials are often cited as additional benefits of attic ventilation. Lack of attic ventilation is routinely blamed for a variety of problems and failures.

Venting rules for attics have been extended to apply to cathedral ceilings, but few studies have been made to confirm the validity of extending them. However, papers presented at various conferences in recent years and summarized in an article in the October 2002 ASHRAE Journal have raised questions about the importance we place on attic ventilation.

Unvented attic construction is indirectly recognized by the Building Code as an acceptable construction detail. Section 9.19 of the NBC recognizes that roof venting can be omitted if it can be shown that it is not needed. The provision for unvented attics was drafted largely to deal with manufactured homes, which can achieve a better level ceiling airtightness than is normally the case in site built construction. However, with new construction practices, it is possible to achieve airtight ceiling assemblies with site-built construction. Although it is still prudent to design for vented attics, unvented ceiling assemblies can provide satisfactory solutions in some cases, especially for cathedral ceilings and smaller roof decks over living spaces.

Sometimes attic vents can be either impractical or undesirable. Closing attic vents may be desirable for sound mitigation, especially near airports. In suburban and rural areas subject to forest fires, roof vents may provide an entry path for sparks into the roof cavity and a fire may spread more rapidly due to the draft in the ventilated space.

A fire in the building housing CHBA-BC offices in Burnaby pointed this out. The fire entered the vaulted ceiling structure through the soffit vents. Its spread was only held in check by a ridge beam that compartmentalized the cathedral roof vent cavity.

It is worth considering how construction practices and designs have changed over the years, as this can also have an impact on a building's performance. Older houses typically were built with large attic spaces, low insulation levels, and were not airtight. Large volumes of air change and considerable heat loss from the house meant low relative humidity levels in the house during winter and low moisture content in the construction assemblies. Cold outside air coming into the attic was heated by the heat loss through poorly insulated ceilings, thus increasing the drying potential.

Today homes are well insulated and more attention is given to air sealing to reduce uncontrolled air leakage. However, the glass fibre insulation commonly used is porous to air leakage. We also use more sophisticated me-

An Ontario Ministry of Municipal Affairs and Housing opinion about the ventilation requirements for roof spaces (Ontario Building Code [OBC] Subsection 9.19, which is the same in the National Building Code) made in May, 1997, stated:

According to Subsection 9.19. of the OBC, ventilation must be provided to all roof or attic spaces. This requirement is intended to provide adequate air circulation in order to avoid air being trapped and condensed. However, it is the opinion of the Housing Development & Buildings Branch that, where a roof assembly is filled with rigid insulation (no gaps or empty space in between), Subsection 9.19. of the OBC need not apply and may be considered to be acceptable under sufficiency of compliance in Section 2.7 of the OBC. This opinion is based on the fact that, if a roof assembly does not contain any air space or air pockets in between, air will not turn into vapour and condense within such an assembly even under extreme weather conditions.

The theory behind attic ventilation is that air movement through the attic will be a drying mechanism for any moisture that accumulates or is trapped in the attic. However, attic ventilation requires heat loss to remove moisture, since cold air cannot hold much moisture.

Winter air has little capacity to absorb more moisture as it is usually at a high relative humidity and the absolute amount of moisture that air at 0°C or colder can hold is very small. Air movement will help remove moisture, but it will not be quick and may not prevent significant condensation in the attic, especially if there is considerable air leakage through the ceiling.

According to the psychometric chart, which plots the relationship between temperatures, relative humidity and moisture capacity, 100 m³ of air at 0°C is only able to hold about 0.4 litres of water. At -10°C the same volume of air can only hold 0.2 litres. However, at 21°C, a typical indoor temperature, the same volume of air can absorb almost 1.5 litres of water.

If the indoor air that is at 21°C and 40% RH leaks out to an attic space which is at -10°C, every 100 m³ of air will deposit about 0.6 litres of water. (100m³ is approximately the volume of a 20 ft by 20 ft room with an 8-ft ceiling).

chanical systems indoors, which often include humidifiers. Houses in the past may have had a relative humidity of 10-15% on a winter day, while today it may be 30-40%. Even a modest amount of air leakage from the house can move significant quantities of moisture into the attic.

It is important to remember that air flows and moisture movement are influenced by climatic conditions. If you plan to build in the southeastern United States, southern Japan or in a tropical or semitropical climate, building practices and details will be different from those that are appropriate in Canada. Even in Canada, although all areas are cold heating-dominated climates, there are differences in the severity of the climate. Climate conditions in southwestern BC and possibly portions of Nova Scotia and southern Ontario are milder than the extreme cold of the Prairies or far north, so specific construction details may be different.

In cold climates the three most effective measures to lower attic moisture conditions are indoor humidity control, airtight ceilings preferably combined with positive active pressures, and attic ventilation. Indoor humidity control can be built-in only to a certain degree, as it is impacted by occupant behaviour. The other two measures are outside occupants' control.

The earliest testing of the effectiveness of attic ventilation was done in the 1930s on model houses indoors in a laboratory, not full-size buildings exposed to actual weather. The results showed that attic ventilation could reduce condensation on roof sheathing during cold weather.

Attic moisture readings taken in the 1940s in Wisconsin found that condensation in the attic occurred only in those houses that had high humidity levels indoors. In all houses, higher moisture conditions in the attic corresponded with higher humidity conditions in the living space.The code ventilation requirement was established by trial and error after the early tests and monitoring studies. With a 1:300 ratio, the attics seemed to be reasonably dry. Studies on attic moisture generally concluded that indoor humidity control is important in reducing condensation in the roof and walls. Ceiling vapour retarders were identified as being effective in lowering attic moisture levels. Some studies suggested that the attic vent area could be lowered to 1:600 if a ceiling vapour retarder were present.

By the 1960s, with a better understanding of the performance of residential buildings, it was recognized that a vapour retarder was not a dependable means of attic moisture control. It is air movement by air leakage through the ceiling into the attic that is the major source of attic moisture. Thus, an air barrier in the ceiling is more important than a vapour retarder.

It is now recognized that attic ventilation above the insulation in a leaky ceiling assembly can draw warm moist air from the interior through air leakage in the building envelope, thus contributing to moisture problems. That is why the ASHRAE Handbook of Fundamentals now stresses the importance of controlling airflow.

Proposed changes to the "International" Energy Conservation Code, which is one of the major building codes in the US, will permit unvented attics if the insulation is air impermeable and the ceiling does not include poly vapour barrier.

To ensure there is no indoor air movement into the attic, the ceiling has to be airtight and the pressure of the attic should be higher than the pressure indoors. In other words, the attic should be pressurized or the house placed under a negative pressure. A house completely under negative pressure could lead to other problems especially if there are spillage-susceptible combustion appliances or soil gases that could be drawn into the house.

Achieving good airtightness can be a challenge due to the many appliances and light fixtures used today. A major problem is the popularity of recessed ceiling lights. As typically installed, each pot light is a significant source of air leakage. Proper air sealing at pot lights requires special care and attention that is seldom achieved in practice unless the builder is setting out to meet a stringent air test such as the test for R-2000 certification. Other penetrations through the ceiling can include wiring and mechanical services running through the attic. Even ceiling mounted fire sprinklers can be a major source of air leakage.

Increasingly, new approaches to construction are being used for houses or for portions of them. These include structural insulated panels and roof systems with foam insulation applied directly to the underside of the roof sheathing. Spray-in-place polyurethane insulation can be both an air barrier and insulation. Lower density spray foam like Icynene and Demilec are good air barriers but are vapour permeable, so will still require a vapour diffusion retarder. However, a polyethylene vapour barrier in such applications is actually too effective a vapour barrier and can impede the ability of any residual construction moisture to dry out, so a more permeable vapour barrier like paint is preferable to permit the moisture to dry into the interior space.

When foam insulation is used in walls and low-slope roof systems, it generally provides good moisture control. If the spray foam is applied directly to the underside of the roof sheathing, there is no moisture performance advantage to venting such roof systems. The spray-in-place foam insulation provides the required insulation as well as performing an air barrier function, thus also controlling moisture migration into a space where it could be harmful. The expanding foam insulation ensures a better, more even and inherently airtight assembly than conventional batt insulation materials because it can fill all voids not otherwise accessible. Because air movement is blocked through the material itself, moisture cannot get into the roof structure, so the structure will be free of moisture problems.

Functionally, spraying foam directly against the interior side of the roof sheathing is the same as structurally insulated (or stressed skin) panels which have been used successfully in thousands of buildings throughout North America.

Attic ventilation in a very cold climate helps makes a cavity roof more moisture-tolerant and should be used as an additional safeguard. However, alternative strategies also are acceptable, especially in the case of older buildings and homes that have shown satisfactory performance or in new buildings where carefully sealed foam insulation is directly applied to the roof sheathing.

In cold climates, cathedral ceiling construction is inherently more prone to moisture damage than attic construction because each rafter space creates its own cavity. That is why code language requires cross strapping in an effort to link all cavities.

The more frequent use of designs with cathedral ceilings and roof decks over living space are details that were not commonly considered when the codes were drafted years ago. Cathedral ceilings, with narrow vent cavities and flat roof and decks over living spaces are not likely to experience the air flows required to create the nominal drying that is achievable in a vented space.

Wind washing of the insulation, when cold air penetrates the ceiling insulation, is another common problem with ventilated attics and cathedral ceilings, especially near the soffit vents. In an unvented cathedral ceiling, the air space required for venting can be filled with additional insulation. This benefit should be weighed against factors that would reduce ventilation effectiveness, the feasibility of foam-based and other unvented assemblies, and the possible detrimental or undesirable effects of ventilation.

In milder cool and wet coastal climates, moisture contained in the outside air is carried into the attic by ventilation and can become a source of moisture.

CMHC studies on the West Coast found that high attic ventilation rates led to higher moisture content in the roof sheathing. The higher

ventilation rates meant colder attics without lowering attic water vapour pressures, resulting in high attic relative humidities and moisture content in the sheathing. The studies suggested that unvented attics perform better in wet, cool coastal climates as long as indoor humidity is controlled by ventilation or dehumidification, and the ceiling assembly is built airtight.

In hot humid climates attic venting tends to increase rather than reduce moisture levels in the attic. When the ceiling is not airtight, attic ventilation may also increase the cooling load in the building.

Ice Dams

Attic ventilation is generally credited for minimizing ice dams. However, it is the heat loss through the ceiling that is a major contributor to ice damming. An Ottawa study found that all monitored houses with ice dams had interior chimneys that warmed the attics which were about 4°C (7°F) warmer than attics of houses without ice dams. Houses with ice dams also tended to have less insulation in the ceiling and less eaves ventilation, either due to fewer soffit vents or fewer insulation baffles at the eaves.

Ice dams can be avoided in vented attics if the attic temperature can be kept below freezing when the outside temperature is -5.5°C (22°F) so that heat from below does not melt the snow on the roof. That is why higher ceiling insulation levels are always beneficial.

The need for attic venting to avoid icing depends on the climate, the amount of insulation in the ceiling, the design of the roof, and solar exposure. To minimize the danger of ice dam formation, heat sources in the attic such as warm chimneys and poorly insulated heating and ventilation ducts as well as warm air leakage into the attic from below must be avoided.

Durability of Shingles and Roof Ventilation

Many asphalt shingle manufacturers require "code-level" ventilation for their warranties to be effective. The rationale is that venting cools shingles and thus affects their durability. However, ventilation is a minor factor in determining shingle temperature.

Shingle temperature is more strongly influenced by the geographic location and the direction a roof faces, rather than ventilation. Venting can cool shingles, but the cooling effect is not strong. US studies have shown that attic ventilation in a black shingle, truss-framed roof assembly has a 2 to 3% cooling effect on shingles, but the effect of colour is 20 to 30%. White roofs have been found to be up to 20°C (36°F) cooler than grey roofs, and up to 30°C (54°F) cooler than brown roofs.

Building Science Corporation in their Build America projects in Nevada and Texas have calculated that the life span of shingles in an unvented roof may be reduced by 3 to 5%. ☼

Do Attics Need Ventilation?

On balance, venting is recommended for cold climates. While attic ventilation can be beneficial, it should not be viewed as the principal strategy to eliminate moisture and other problems in the attic and roof in all climates. Attic ventilation needs to be part of broader range of moisture control strategies.

- ☞ Indoor humidity control should be the primary means of limiting moisture accumulation in attics in cold and mixed climates.
- ☞ Unvented roofs can perform well in cold and mixed climates if measures are taken to control indoor humidity, to minimize heat sources in the attic, and to minimize air leakage into the attic from below.
- ☞ Ventilation should be treated as a design option in cold, wet coastal climates and hot climates. Current technical information does not support a universal requirement for the ventilation of attics or cathedral ceilings in these climates.

Guidelines for Seismic Evaluation of One & Two Family Dwellings

Many parts of Canada are in zones of high earthquake potential. Although these areas may not be as seismically active as California, Japan or the Middle East, the potential is still there. In recent years, more attention has been given to the subject, especially in southwestern BC where geologists suggest the area is overdue for a major tremor.

Engineers study the performance of buildings after each major earthquake anywhere in the world. A review of the survivors as well as damaged structures adds to the understanding of structural performance in an earthquake. As a result, structural design for seismic loading has improved significantly in recent years. New buildings built according to the latest practices are far better able to withstand major earthquakes.

The Building Code requires that buildings must be adequately designed for the loads they may experience. In areas of high seismic activity or high wind loads, the structures must be designed to properly withstand the forces that may impact the building. The City of Vancouver Building Bylaw (which is essentially the same as the National Building Code) exempts one and two family dwellings from the engineering design provisions of Part 4 when these are built in accordance with the prescriptive requirements of Part 9. This does not mean that Part 9 buildings are exempt from compliance with the proper structural design requirements to accept wind and earthquake loads. Rather, this exemption recognizes that traditional residential building designs have a lot of load sharing between many non-structural elements which help the building stand up to wind and earthquake loads.

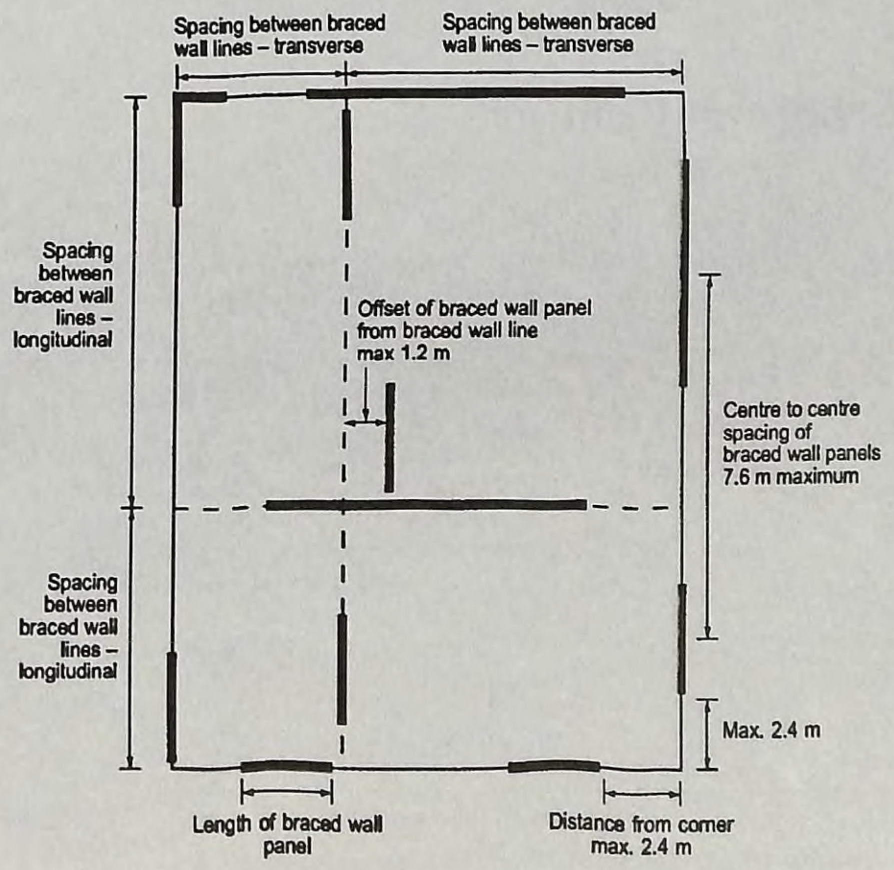
What has not been recognized, however, is that current house designs, which have moved away from traditional design forms, are moving away from the assumptions behind the building code requirements. Today's homes feature the use of large span framing systems, large glass areas, and open floor areas with fewer interior partitions, including double or triple garages with living spaces over, so that many of the assumptions on which Part 9 is based are no longer valid.

The City of Vancouver has recently stepped up enforcement of seismic design. They have issued a bulletin with guidelines that are based on the Canadian Wood Council's (CWC) *Engineering Guide for Wood Frame Construction*. The intent of the guidelines is to provide a tool to assist designers in identifying conditions and building designs that may require special attention.

This Guide uses the idea of "braced wall panels" and "braced wall lines" to determine how much structural redundancy a building has. Although not referenced in the National Building Code of Canada, the CWC Guide is now considered as a national standard for small wood frame buildings, particularly with regard to determining when additional design is required.

Braced Wall Panels - sections of walls built in a way to provide some resistance to lateral loads

Braced Wall Lines - a number of braced wall panels used in combination within the limits identified in the CWC Guide.



The basic design principle is that when braced wall panels have adequate strength and spacing for the load conditions, there is enough redundancy built into the system and the lateral design requirements will be satisfied. Roof and floor elements must be sheathed with enough strength and rigidity to act as diaphragms. This requires panel-type sheathing or continuous lumber sheathing applied diagonally.

The CWC Guide shows the maximum spacing between braced wall lines for specific lateral loads. One and two family dwellings are assumed to meet the seismic design requirements if:

- the building area does not exceed 600 m².
- the building height does not exceed three stories.
- the maximum spacing for wood studs and joists is 600 mm o/c
- the clear span of framing members is not more than 40 feet (12.2 m)
- the design load of floors is not more than 50 psf (2.4 kPa).

There must be enough built-in redundancy in the structure. In order for the plan to meet this requirement, the following conditions should be met:

- the perpendicular distance between braced wall lines must not be more than 25 ft. (7.6m).
- the offset of any braced wall panel within the braced wall line must not be more than 4 ft. (1.2 m).
- any braced wall panel must not be more than 8 ft. (2.4 m) from the corner of the building.
- the spacing of braced wall panels along the braced wall line must not be more than 25 ft. (7.6 m).
- the minimum length of any braced wall panel is 4 ft (1.2 m).
- all exterior and interior braced walls must be supported on continuous foundations.
- the maximum height of any knee wall (cripple wall) is 4 ft. (1.2 m).

If the design meets all of these requirements, it is assumed to meet lateral wind and seismic loading. If the design does not meet all of these requirements, then a design review must be done, and some additional detailing may be required. ☼

Thermal Comfort

We normally look to the air temperature, which is measured by a standard thermostat, as the indicator of comfort conditions. However, comfort conditions are much more complex. Comfort depends on a combination of air movement, humidity, the temperature of the surfaces surrounding us (referred to as the *mean radiant temperature*) as well as the temperature of the air.

All heating systems rely on the three heat transfer mechanisms – convection, conduction and radiation. The degree to which each is important in a given type of heating system differs. The radiant heat component is more important in low temperature heating systems than it is in other systems. Because the heat transfer accounted for by convection is lower, the air temperatures can be 1-2°C lower to provide the same comfort level.

Some studies show that people find interiors to have a better air quality and not to be as stuffy when air temperatures are lower. Mucous irritation complaints increase significantly when air temperatures go over 22-24°C. The annoyance from all kinds of volatile chemical emissions (VOCs, etc.) has been correlated to the air temperature. A relationship has also been found between Sick Building Syndrome and the air temperature.

Thermal Comfort Formula
Air temperature (°F) + Mean Radiant Temperature (°F) = 140°F

Computer simulations and laboratory and field experiments done for the International Energy Agency (IEA) found that there is a difference in the temperature gradients between the floor and ceiling in rooms heated by floor radiant heating systems compared to high temperature baseboard radiators. Rooms in well-insulated buildings with floor radiant heating have very even temperature distribution. On the other hand, temperature distribution in rooms with high temperature radiator systems is very dependent on the system design. Normally, gradients range from 2-3°C between floor and ceiling, while in poorly designed systems the difference can be as much as 7°C between floor and ceiling.

It is the temperature difference in the zone between the ankles and the head level that affects the perceived thermal comfort. Radiant heat transfer which has relatively cool air temperature but warm surrounding surfaces better satisfies the comfort needs of human beings because it is more "natural" – like solar radiation on the skin.

A heated floor makes it more comfortable when people walk barefoot. Optimal floor temperatures range from 20-28°C if people walk with shoes and 23-30°C with bare feet depending on the floor material.

The IEA studies were done in Europe, where most heating is done by baseboards or floor radiant heating. The forced warm air heating commonly found in North American homes helps reduce temperature stratification by forcing air movement which tends to mix the air in the house. Good performance is achieved when the furnace blower is run continuously at low speed.

Conventional forced warm air or high temperature baseboard heating systems have a shorter heating-pickup period after cooling down with a setback thermostat because of these systems' low thermal capacity. They will raise the air temperature up to the set-point fairly quickly, but this may still not be enough to provide comfort because of the thermal lag of the cold building materials. For comfort conditions, the mean radiant temperature is very important, and the time to warm cool building materials means it takes longer for the mean radiant temperature to rise.

Large temperature fluctuations, like large temperature gradients between floor and ceiling, are annoying for people. It is one of the reasons why poorly sized forced warm air heating systems often generate complaints, because the furnace may cycle infrequently. Low temperature radiant heating systems have less fluctuation because heat is stored in the building materials, especially in the thermal mass floor toppings, leading to more even temperatures.

Generally, radiant systems operate at small temperature differences, so any change in the indoor temperature will quickly shut off the heat supply, but other heat gains may not be as controllable. The thermal flywheel of building materials can cause discomfort during periods of high solar gains or sudden changes in internal gains, so the building and building envelope have to be designed carefully.

Higher building insulation levels, lower infiltration losses and solar gains can increase the risk of overheating during the summer. Proper building design is needed to avoid overheating problems. Heavy masonry materials, such as brick feature walls and concrete floor slabs with tile or stone finishes are very effective at soaking up excessive heat gains and acting as a heat storage medium. This is an important principle of passive solar design.

Windows

Cold window surfaces can make rooms uncomfortable because of the radiant heat losses to them as our bodies become the heat source to the colder surface of the window. As well, drafts can be caused by larger window surfaces when the boundary air layer at the glass cools and flows downwards. The traditional way to compensate for the cold surfaces is to place heating registers or radiators close to or under the window. This discomfort can also be reduced by limiting window dimensions to a reasonable size. Use of high performance windows also helps improve comfort.

In the case of radiant heating systems, low R-value (high -U value) windows, because of their greater heat loss and colder surface temperatures, require more care when the system is being laid out. Very large window areas may have to be reduced when radiant heating is used, although extra heating pipes can be placed close to the outer loops of a floor heating system to compensate for the greater heat loss to ensure that discomfort does not occur.

Indoor Air Quality

Inhaling dust can cause allergic reactions. Human sensitivity to inhaled particles is more dependent on the quality of the particles than on the quantity. At temperatures exceeding 55°C, the process of dust singe starts. The particles get more reactive and irritating from the higher temperatures that occur at high temperature heating elements such as electric or hot water baseboards.

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000 www.R-2000.ca

Low temperature heating systems not only emit less suspending particles into the air but also the particle spread is less aggressive due to absence of dust singe. A study in Finland found that visible dust on floors correlated with complaints such as chronic headaches, fatigue, and problems with concentration. Low temperature radiant heating systems were found to reduce eye-irritation and throat and other mucous diseases.

A relationship was also found between the temperature of the heating surface and particle deposition, such as is often seen above high temperature hot water or electric baseboard heaters. It is thought that the lower air temperature fluctuations from radiant systems result in a lower quantity of suspended particles in buildings. On the downside, radiant systems do not have the air circulation systems that make it easier to add filters to clean the air.

Many studies have found that floor radiant heating is beneficial in reducing dust mite concentrations in homes. This is mainly because of the lower relative humidity (RH) in the boundary layers above the floor and within the floor covering. To survive, mites need an average relative humidity of 45% or more over the long term. Calculations have shown that floor heating reduces the RH in the boundary layer by about 10%, which can be enough to bring the RH below the threshold value. ☼

Continuous Ventilation: The Heart of a Healthy House

"I have to admit that when all our ailments and allergies cleared up after the HRV was installed at our old house, I was sceptical.

Well, I truly eat humble pie now and I apologize I ever doubted you! The HRV has been hooked up five days now and the eczema (which reappeared upon moving), is almost gone; Andrew's stopped snoring; Emily has stopped waking up stuffed up, and Ben stopped wheezing! Plus my arthritis has gone.

Wow!

Thanks for the wonderful Christmas present!"

Testimonial letters from past customers are the most valuable marketing tools anyone selling a service can have. They are especially valuable when they arrive unsolicited. This is a tale of a testimonial that a Vancouver ventilation equipment distributor received. While it is anecdotal, it confirms the observations that R-2000 builders make, and emphasizes that a well-built home can be a healthier home.

In this case, the homeowners had installed a heat recovery ventilator in an older house. They had lived in their home for some time before installing the HRV, so they had the experience of the home without continuous ventilation.

The home was a typical Abbotsford, BC home built in the mid 1980s. The house had 1,200 sq. ft. on the main living level over a 1,000 sq. ft. walkout basement and a 200 sq. ft garage on a sloping lot. The home was heated by a gas forced air furnace located centrally in the basement. The house was not airtight, and had high relative humidity even after the perimeter drainage was dug up and relaid. Winter relative humidity was observed to range from 54 to 74%. The windows on the lower level had a lot of condensation, and the sashes remained wet and were mouldy.

In that house, the family of four had all experienced a degree of low-level chronic health problems. The 10-year-old son was the major exception as he is an asthmatic and had frequent attacks in the winter. He had suffered from asthma for many years. His triggers were grass, pollen, dust and mould. His prescribed medication included inhaling two Salbutamol puffers in the average 100-day winter period. This represented two doses/day increasing to five doses/day during a crisis. A corticosteroid puffer would often follow at two doses per day for three to four weeks after a crisis. Sometimes home treatments were not enough. At least one emergency trip to the hospital per season was required.

The 8-year-old daughter's allergies were expressed in the form of eczema on her hands and both upper and lower legs. The mother also was bothered by eczema, often having raw and bleeding hands. The father was almost always congested but not nearly as affected as his son.

In September of 1999 the family had an Eneready 2000 HRV installed in their home. It was ducted to exhaust the kitchen and two bathrooms and to directly supply fresh, pre-warmed air overhead to the bedrooms and the living, dining and recreation room.

During the first three weeks after the HRV was installed, more than 4 gallons of water was removed as it helped dry out the house. The relative humidity in the house dropped by about 10% to a range of 45-54%. This solved the window condensation problem and improved the indoor air quality.

The family discovered they had more energy, while the boy could reduce the amount of medication he took – only occasionally using his puffer. The daughter had a marked decrease in her eczema and the mother's eczema disappeared. All felt that their home was fresher. Even guests noticed the difference.

The family noted that they had made no change to their diet, routine, or medications that could have contributed to their improved state of health after installing the HRV. This family's experience showed that the quality of indoor air improved by the continuous exchange had a significant effect on family members' health, each in different ways.

After four years in that house, last year the family moved to a new (but not a brand new) home. Their new house did not have a central ventilation system, and all their chronic health symptoms returned. After a few months, they installed an HRV, again set to operate continuously. Within a few days, they noted a significant improvement to their home and to their family's health.

This is what generated the note the HRV supplier received just before Christmas. ☼

Today we are very concerned about the food we eat. We eat about 1 lb. (dry weight) of food each day.

For the past few years, we have been concerned about the water we drink. We drink about 5 lb. of water each day.

Each day, the average adult inhales 54 lbs. of air every day. We are not fully aware of this (maybe because unlike for food and water, we don't yet directly exchange money for this).

Perhaps the quality of the air is equally as important as the quality of the food and water we consume.

BCBuilding.info

BCBuilding.info is a free, e-mail newsletter issued every three weeks, serving the residential construction industry of British Columbia. Although its focus is on BC, the newsletter may also be of interest to builders in other parts of the country.

Each issue contains a focus on a specific topic as well as short articles written for builders and renovators with links for more detailed information. Past issues are archived on the BC Building Web site. Some of the topics covered in past issues include: Flooring; Insulation; Green Building; Doors & Hardware; Building Science; Exterior Finishing; Roofing Systems; Energy Efficiency; Ventilation & Indoor Air Quality; Foundations & Basements; Heating Systems; Advanced Framing & Wall Systems; Windows; Building Envelope Resources.

A unique feature of the electronic newsletter is that it does not present articles as such, but rather a one or two sentence summary of a topic with a number of links to other Web sites where more detailed and topical information can be accessed. In this respect, it is very much like an annotated bibliography, saving readers a considerable amount of time when searching for information.

Ken Farrish, a building industry veteran and past president of the Greater Vancouver Home Builders Association, is the person behind BCBuilding.info. He set out to provide BC builders and renovators with resources to help them build the best quality buildings possible.

Information: www.bcbuilding.info

Technical Research Committee News

Canadian Home Builders' Association

Arc Fault Circuit Interrupters

The Canadian Electrical Code now requires the installation of an arc fault circuit interrupter (AFCI) on all bedroom electrical circuits. This has created a lot of concern about extra cost as well as doubts about how effective arc fault circuit interrupters may be.

What Is An Arc Fault And Why Is It A Concern?

An arc fault is an unintended arc flowing through an unintentional path. Common causes of arc faults in a home include:

* Loose or improper connections, such as electrical wires to outlets or switches
* Frayed or ruptured appliance or extension cords
* Pinched or pierced wire insulation, such as a wire inside a wall nipped by a nail or screw or a chair leg sitting on an extension cord
* Cracked wire insulation stemming from age, heat, corrosion, or bending stress
* Overheated wires or cords
* Damaged electrical appliances
* Wires or cords touching vibrating metal
* Electrical wire insulation chewed by rodents

Arcing generates high intensity heat, which can easily ignite combustible materials. Arcs can happen anywhere in the electrical system – in the fixed wiring behind the walls, in extension cords, within receptacle boxes, or in the end appliance. When wire insulation breaks down, the arcing circuit becomes so hot that parts of the wire can soften and sputter by the force of the arc, which can then ignite nearby combustible materials.

It is estimated that on a typical day in Canada there are 40 fires of electrical origin, one third of these resulting from arc faults, sometimes causing injury and death.

Arc faults escape detection by traditional circuit breakers because the arc fault current may not be consistent enough or high enough to trip a conventional breaker. Typical household fuses and circuit breakers do not respond to early arcing and sparking conditions in home wiring. By the time a fuse or circuit breaker opens a circuit to defuse these conditions, a fire may already have begun.

What Do AFCIs Do?

Arc fault circuit interrupters are able to detect certain types of dangerous arcing conditions. They look and work just like conventional circuit breakers and fit into electrical panels in the same way. They protect against overloads and short circuits and also electronically sense arcing. AFCIs were first developed by electric utilities to deal with downed power lines.

Arc fault circuit interrupters are now required in the Canadian Electrical Code for installation on all bedroom circuits. State Farm Insurance suggests that AFCIs be used in older homes that may have aged or damaged electrical wire insulation. Others have suggested that AFCI may be a good safety feature for use in homes that have aluminum wiring.

Arc Fault Circuit Interrupters vs. Ground Fault Circuit Interrupters

AFCIs are not to be confused with ground fault circuit interrupters or GFCIs. Both are safety devices but each has a different function. GFCIs provide protection from the serious consequences of electric shock. AFCIs are intended to address fire hazards.

AFCIs can be installed in any 15- or 20-ampere branch circuit and are available as circuit breakers with built-in AFCI features. ☼

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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Building Science Spring Training Camp April 18-20, 2004

Shake off the cobwebs after winter hibernation

Last year Tex McLeod, an Ontario housing consultant and R-2000 trainer, had the idea for a building science spring camp. The event was a sellout, despite a late burst of winter that made access over icy roads hazardous. Feedback from participants who came from all parts of Canada was overwhelmingly positive. Planning is well underway for this year's spring camp which is to be held in Ottawa, where we can take advantage of the technical resources available there. A post conference day (April 21) will offer an optional program of building science activities in the Ottawa area.

Spring Camp 2004 once again will bring together some of North America's leading building scientists and educators along with some of Canada's most dynamic innovative builders. The event starts with a "get to know you" opening reception on Sunday evening April 18, with two full days of sessions Monday and Tuesday. Topics that will be discussed in some depth with leading experts will probably include mould and healthy housing, effective mechanical systems, and combustion safety in home appliances. Specifics will depend on where the experts leading the discussions and the participants take the topics. We will also visit some world-class research facilities in Ottawa that have been so instrumental in the development of Canadian building science research. At press time all details have not completed, so we can't give you names of the speakers.

We are putting finishing touches on an all-inclusive package that includes an opening reception on Sunday night, the seminars Monday and Tuesday, accommodation and all the hospitality and great meals. Send in your application today! Just like real spring training camp, you have to be invited. We've only got space for about 70 and we need to ensure a good mix – the right amount of salt & pepper, scotch and chocolate. Let us know something about yourself and why you want to attend. Bribery or other payments above (or under) the table will not be considered.

Spring Training Camp is organized by Enerquality Corporation and Mcleod Associates in association with the Ontario Home Builders Association, Solplan Review, and the University of Waterloo. Sponsors include the EnerQuality Corporation and the McLeod Associates in association with OHBA, University of Waterloo, Solplan Review, NRCan, CMHC, and NRC.

For more information, and to register, contact Susan Woolsey at the OHBA, 20 Upjohn Rd., Toronto, ON M3B 2V9; fax 416-443-9982; e-mail: swoolsey@ohba.ca

NRC·CNRC

IRC Studies on the Control of Rain Penetration in Exterior Wood-frame Walls

By Michael A. Lacasse

This article is an extract from a paper and talk authored by Dr. Michael Lacasse, presented at IRC's Building Science Insight 2003 seminar series held across Canada from October 2003 to January 2004. Dr. Lacasse is a senior research officer in the Building Envelope and Structure program of the National Research Council's Institute for Research in Construction.

A key requirement for exterior walls is the control of rain penetration. Lack of attention to design principles or failure to implement them in the detailing of the wall assembly may lead to premature deterioration of wall elements. Over the past four years, NRC's Institute for Research in Construction carried out experimental work on the watertightness of 17 wall assemblies to determine how deficiencies in the wall systems might affect the water deposition rate into the stud cavity. This research was part of the Moisture Management for Exterior Wall Systems (MEWS) project (Solplan Review, No. 113, November 2003).

The wall specimens combined different types of cladding, sheathing membranes and boards, and insulation of typical use in North American construction. Cladding types included stucco, brick veneer, hardboard and vinyl siding, and exterior insulation and finish systems (EIFS). Certain cladding systems included a clear continuous air space. Sheathing boards included glass mat gypsum board, oriented strand board (OSB), fibreboard and XPS (extruded polystyrene) foam sheathings (Figure 1). Deficiencies included discontinuities of rain penetration control elements at junctions with windows, ventilation ducts and electrical outlets, such as a missing length of sealant or construction tape.

Researchers subjected each wall specimen to simulated wind-driven rain of various intensities in IRC's unique Dynamic Wind and Wall Testing Facility (DWTF) and investigated how much water got deposited in the stud cavity under a variety of climate loads (Figure 2).

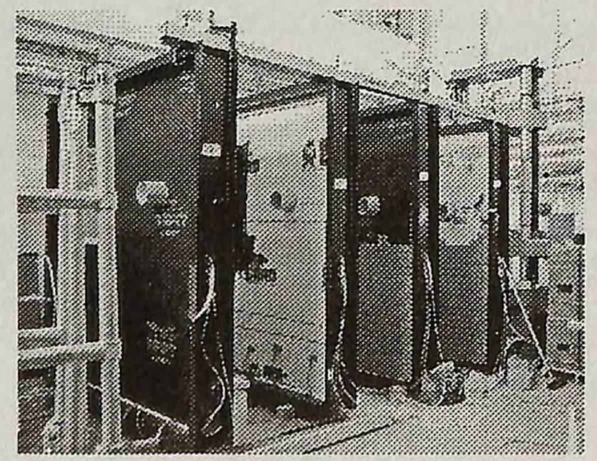

Figure 1. Full-scale 2400-mm by 2400-mm test specimens shown at different stages of fabrication. Four of the 17 wall specimens included brick veneer.

Conditions for Rain Penetration

For water to enter into the wall assembly, three conditions must be met: the presence of water on the facade, a force to drive it inwards and an opening providing a path for water to flow. The forces acting on the façade to cause water penetration are: gravity, capillary action, air pressure difference, surface tension, and kinetic energy of the raindrops. Two key climatic factors to include in a laboratory testing program are wind speed and rainfall intensity. Higher wind speeds cause a greater air pressure differential across the wall and cladding elements, which will cause the water present at deficiencies in the cladding assembly (e.g., missing length of sealant) to infiltrate the layers of the wall. Deficiencies are often found at the interface between the wall and openings for windows, ventilation ducts and electrical outlets and thereby potentially offer a direct path for water entry.

Simulating Wind-driven Rain in a Laboratory Setting

Watertightness performance testing should be based on climatic design criteria such as those given by ASTM and the rainfall intensities and wind speeds expected in a given location. In IRC's test facility (Figure 2), a continuous spray of water is applied on a wall specimen while subjecting it to a specified air pressure differential. This test is useful for determining loads at which failure may be observed, the nature and location of the failure, and insights into the vulnerability of different wall components to water entry.

For the MEWS project, the watertightness performance test used a series of different spray rates and air pressure differentials to simulate extreme wind-driven rain intensities. These included spray levels typically used in industry performance tests and a range of pressure differentials representing expected occurrences of elevated wind speeds across Canada and the United States. In a typical test, deficiencies, such as missing sealant at interfaces with windows, ventilation ducts and electrical outlets, were incorporated in a test specimen and water was sprayed on the wall. The water entering through the gaps was collected in troughs located in the stud cavity directly below the penetrating component.

Benefits of a Drained Air Space Behind the Cladding

One aspect of the laboratory investigation examined the benefits of a drained clear cavity behind the cladding. Results showed that a clear drained air space behind the cladding considerably reduced the water load into the stud cavity of the wall. Figure 3 shows a sectional view at a ventilation duct penetration of a wall test specimen having two different cladding configurations: one with a clear air space (use of vertical furring strips) and one without it. Water infiltration into the stud cavity was permitted by leaving out sections of sealant at the junction between the wall and the ventilation duct, providing a path for water to get in. A large portion of the infiltrating water was drained into the clear air space behind the cladding, where it could be evacuated outside through the use of proper flashing techniques. The water load into the stud cavity was about 10 times less for the specimen containing a drained cavity (Wall B) as compared to the one without it (Wall A).

In Canada, the installation of a clear drained cavity behind cladding systems has been considered a best practice in the application of the rainscreen principle that was formulated more than forty years ago. It provides a level of redundancy in the wall assembly for rain penetration control because of its capability to provide three key control mechanisms: drainage of incidental water entry, a capillary break to trapped water, and its potential for reducing pressure differentials across the cladding.

Interestingly, the IRC test results also indicated that even with the presence of this clear, drained cavity behind the cladding, a small quantity of water could still find its way into the stud cavity. The path for water leakage was provided by the presence of discontinuities at the junction between the ventilation duct and the water-resistive membrane acting as the second line of defence against rain penetration. Even when an air space was present behind the cladding system, it was beneficial to ensure that the component of the assembly acting as second line of defence, be it a water-resistive membrane or a board stock material, be attached in a water-resistant manner to penetrating elements such as ventilation ducts, electrical outlets and windows, to ensure the continuity of this second line.

Conclusion

Including an air space behind the cladding and ensuring the continuity of the water-resistive layer on the outside of the stud cavity are two design strategies that promote the long-term service life of the structural elements of wall assemblies. ☼

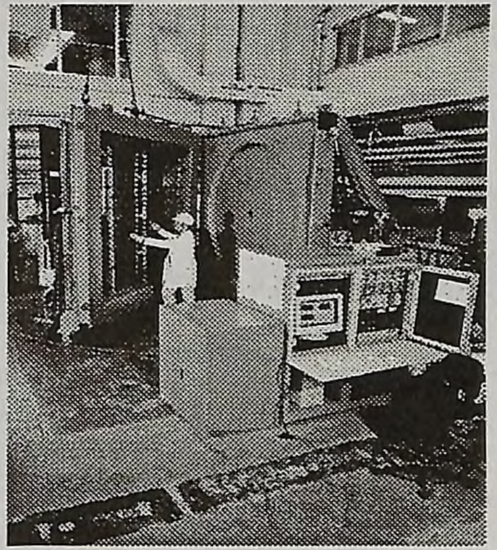

Figure 2. IRC researchers use the Dynamic Wind and Wall Testing Facility to expose wall specimens to wind-driven rain loads and investigate where (and how much) water gets deposited into the layers of the wall assembly. The facility comprises a water spray system that simulates the action of rain; a blower to simulate wind effects; and a piston that, through its cyclic action, varies air pressure to simulate wind gusts.

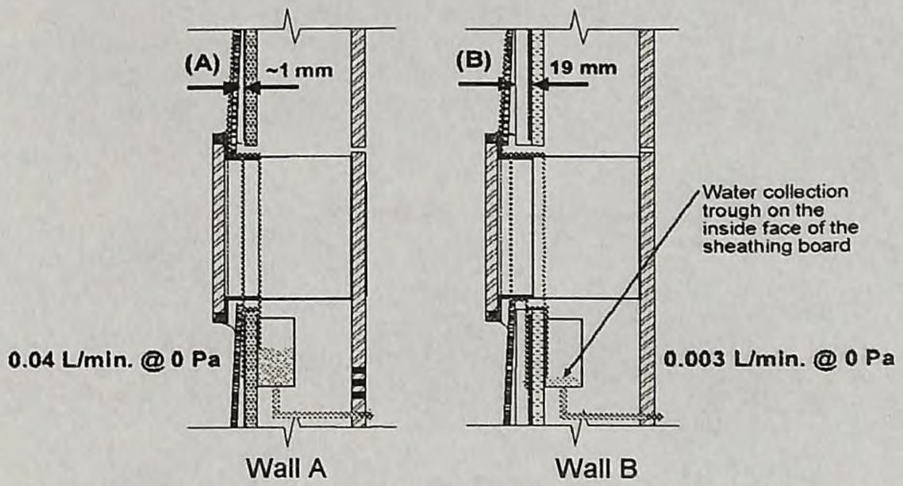

Figure 3. Cross-sectional view of two siding-clad wall sections at the ventilation duct penetration. Wall A did not have a clear continuous air space over the height of the wall, whereas Wall B included a clear 19-mm air space

Further reading

Exterior wall design using the rainscreen principle has been documented in several *IRC Construction Technology Updates*, such as nos. 9, 17, 23 and 34. These can be downloaded from the IRC Web site: *http://irc.nrc-cnrc.gc.ca/catalogue/ctu.html*

MEWS project reports and related articles can be found on the IRC Web site at *http://irc.nrc-cnrc.gc.ca/bes/mews/index.html*

Energy Answers

Rob Dumont

I want to heat domestic hot water using a copper coil passing through a large water tank filled with solar heated water. How big a copper coil should I use?

The diagram in figure 1 shows the application. On my own house, I have such a solar tank with a copper heat exchanger to extract heat for the domestic hot water. The heat exchanger is shown on the right-hand side of the large storage tank. With this type of heat exchanger, there is only one pass of the cold water through the coil. Many other types of heat exchange systems recirculate the fluids (as is shown on the glycol-to-water heat exchanger on the left-hand side of the large tank.)

One of the interesting things about this question is that there is no one right answer. It is akin to the question of how much life insurance one should have, or how much insulation one should have in the attic.

I checked with a number of sources to see their recommendations. Here they are:

In *The Solar Water Heater Book*, Bryenton, Cooper, Mattock and Lyster recommend a 3/4-inch nominal (7/8-inch outside diameter) soft copper pipe 100 ft long.

In the Davis Energy Group design manual for large (500 gallon plus) membrane-lined solar storage tanks, they recommend 2 parallel ½-inch nominal (5/8-inch outside diameter) pipes, with each pipe 75 feet long.

A Canadian solar installer that I spoke with said that he installs a 60-foot long 3/4-inch nominal pipe.

Three answers to the same question.

I went back to the theory to see if some answers could be garnered.

Ideally, you would want the water exiting the pipe equal in temperature to the tank temperature. Unfortunately, you would need a very long pipe to achieve this. The attached graph shows the effectiveness of a cross-flow heat exchanger with one fluid mixed as a function of a parameter called the Number of Transfer Units (NTU). For this type of heat exchanger, you want to get an effectiveness value close to 100%. In general, a higher NTU value will give you a higher effectiveness value. Note that there are diminishing returns, however. Doubling the NTU value does not double the effectiveness.

The NTU is defined as follows

$$NTU = \frac{A}{(R*M*C)}$$

Where

A = surface area of the heat exchanger (square feet or square metres)

R= thermal resistance between the two fluids (hr-ft^2 F/Btu or m^2 K/watt)

M= mass flow rate (lbs water per hour or kg/second)

C = specific heat of water (1.0 Btu/lb-F or 4180 Joules/kg C)

To get a high NTU value in this type of demand heat exchanger, you must use a large surface area A or a low flow rate M.

In a typical house, the maximum mass flow rate of hot water is about 15 litres/minute (3.3 imperial gallons per minute) from a single tap. I checked this recently using the second hand on my watch and a milk container on the hot water tap in our bathtub at home. The kitchen sink hot water flow was 4 litres/minute. The hot water draws from a laundry machine or a dishwasher are also about 4 litres/minute, according to a recent publication.

The thermal resistance for the heat transfer from the water in the large tank into the water in the copper pipe is around 0.0066 hr-ft^2-F/BTU units, according to my old university heat transfer textbook. Note that this is a very small resistance compared to an inch of glass fibre insulation, which has an insulating value of about R3.5. Water is a much better conductor of heat than air, thus the low thermal resistance. However, the low resistance of the copper coil/water combination is not zero.

If we assume a ¾-inch copper pipe, 100 feet long, with a water flow of 3.3 imperial gallons per minute (1980 lb/hr), with a thermal resistance as quoted above, the NTU value is equal to 1.5.

With that NTU value, the effectiveness is equal to about 78%. In order to get an effectiveness of about 90%, the pipe would have to be lengthened to about 150 feet.

An alternative approach is to use two ½-inch copper pipes in parallel. With this approach, the flow rate per pipe is cut in half. If we use two 75-foot lengths in parallel, the NTU value is 1.85 and the effectiveness is about 82%. In order to get 90% effectiveness, the length of the pipes would have to be increased to 93 feet each, or 186 feet in total.

In order to get the effectiveness up to 99%, you would have to double the length of pipe compared with the 90% effectiveness. Diminishing returns definitely comes into play with heat exchangers.

I would argue that it is worth going for the 90% effectiveness heat exchanger. Collected solar energy is a precious commodity, and extracting as much energy as possible is desirable to minimize the auxiliary heat that has to be supplied by conventional sources. Designing for 90% effectiveness at the highest flow rate ensures a higher effectiveness at lower flow rates.

I checked with a pipe supplier, and a ¾-inch soft copper pipe 150 feet long costs about $200.

Although not cheap, this pipe cost is relatively small compared to the cost of a good solar system (approximately $4000 to $5000) and will ensure that a high proportion of the solar heat is well used. ☼

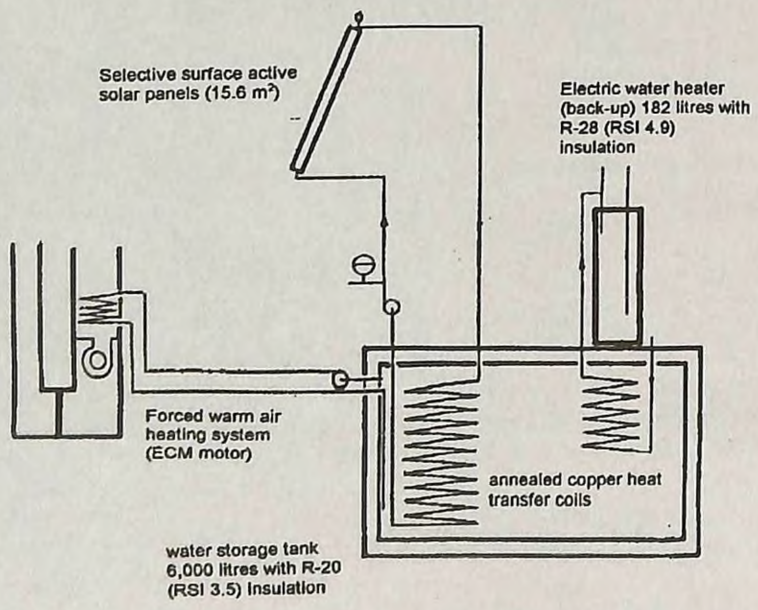

Figure 1. Solar System with large water storage tank and copper heat transfer coils

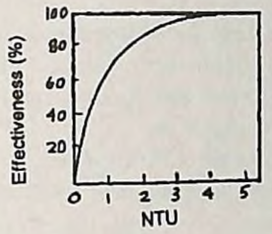

Figure 2 Heat Exchanger Effectiveness vs NTU

First Canadian Residential Fuel Cell Demonstration

A 5-kilowatt fuel cell manufactured by Fuel Cell Technologies Ltd. will be installed at the Canadian Centre for Housing Technology (CCHT) at the National Research Council campus in Ottawa. It has the capacity to generate 5 kW of electricity and 6 kW of heat on-site for home use. Natural Resources Canada is contributing funding to the project to demonstrate the first installation of a residential fuel cell in a house in Canada.

The solid oxide fuel cell unit can use a variety of fuels such as natural gas, methanol, hydrogen, propane, and heavier hydrocarbons to generate electricity and heat without combustion. This co-generation capability creates an overall energy efficiency of about 90%, when all energy losses throughout the system are considered. This compares to an operating efficiency of about 35% for conventional power and heating systems.

The solid oxide fuel cell system operates at 700°C to 1000°C. Similar to existing oil and gas furnaces, it converts hydrocarbon fuels directly into electrical energy and heat but without using a combustion process. As a result, the fuel cell is more fuel-efficient and has lower emissions than conventional power sources such as internal combustion engines, gas turbines, and steam turbines. For every 100 units of energy that enter the fuel cell system, the appliance produces 50 units of electrical power and 50 units of energy liberated as heat. Some of this heat is required to keep the fuel cell at operating temperature and the remaining heat can be used to heat water and/or air.

The CCHT house is a technically sophisticated facility that can simulate occupancy. A virtual family makes demands on the house as its members carry on normal household activities. This means that the fuel cell will have to respond automatically to the demands of a typical household during each

of the winter, summer, and shoulder seasons.

Over the term of the demonstration, the expertise of CCHT's personnel and the monitoring capabilities of the CCHT facility should provide feedback on the operation of the residential fuel cell.

The fuel cell unit is a solid oxide fuel cell power system manufactured by Fuel Cell Technologies Ltd. of Kingston ON. FCT is a leading developer of small-scale power systems (1 kW to 50 kW) that provide on-site generation of electricity. Their power units can operate on any one of several readily available fuels to provide electricity and heat for stationary applications such as houses, small commercial enterprises, industrial applications, and remote sites.

For a homeowner, the expected payback period on a commercial system is estimated to be four years. The size of the 5 kW commercial system will be similar to that of a home furnace. Units will initially be available in low volume production. The price is expected to approach $1,000 per kW when high volume production and full commercialization are underway. ☼

For further information contact:
www.fct.ca

MemBrain™, The Smart Vapor Retarder

MemBrain™ is a unique vapor retarder made from a polyamide (nylon-6) film that changes permeability according to relative humidity. It varies from less than one perm (57ng/Pa-s-m²) at 20% relative humidity (RH), as would be found during winter months in a cold climate, to more than 10 perms (1,144ng/Pa-s-m²) at 70% RH and over 20 perms at 95% RH. This process allows closed building envelope systems to increase their drying potential with seasonal climatic changes. MemBrain reacts to relative humidity by altering its pore size, allowing water vapour to pass through it. When conditions change and relative humidity increases above 60%, the pores in the material expand and its permeability increases. This transformation permits drying to occur in either direction, through vapour diffusion. Thus, its lowered resistance value supports the drying process, decreasing moisture accumulation within the construction and potential moisture damage.

This product can be used in place of traditional vapour retarders with unfaced fibre glass insulation to provide an insulation system that is ideal in some of the more severe climate condition areas in terms of both temperature and humidity. It protects against condensation in the winter, while allowing for the drying of the building envelope in the summer, when humidity levels are typically much higher. The 2-mil-thick, high-tensile-strength sheet is stronger and more durable than standard 6-mil polyethylene.

This product is not for use with specialty-conditioned spaces where relative humidities are intentionally kept at more than 50% or spaces such as indoor spas or swimming pools. Its performance in rooms with short peaks of high humidity, such as bathrooms and kitchens, will not be affected because of the buffering action of interior finishes.

Interior finish materials and cavity-fill insulation must also be highly permeable (for example, unfaced fiberglass and vapor-permeable paints). The drying benefits of MemBrain will diminish with the use of low permeance finishes so it should not be used where low permeance interior finishes such as vinyl wallpaper or vapour retarder paints are used.

This is the smart vapour barrier we featured in Solplan Review (No. 108, January 2003), and is now being manufactured and marketed in North America by CertainTeed Corporation

Information:
Phone: 610-341-7739,
Toll-free: 800-233-8990
Fax: 610-341-7571
www.certainteed.com

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